Q-CPR® Measurement and Feedback with CPR meter

Application Note





Introduction

Consider the following:

- Research demonstrates that the quality of cardiopulmonary resuscitation (CPR) has a direct effect on survival rate and patient outcome from cardiac arrest.[1,2]
- Research also indicates that caregivers, on the whole, often do not perform CPR within established guidelines associated with compression rate, depth, and complete release, as well as *no compression* activity (or "hands-off" time), and ventilation rate.[3,4]

These statements relate directly to the need to establish appropriate tools and techniques to achieve a higher level of CPR quality. Q-CPR® measurement and feedback technology by Laerdal represents one such option and is the focus of this application note. Specifically, this note provides an overview of studies showing why Q-CPR could be valuable to any BLS or ALS caregiver performing CPR and, as a result, positively influence patient outcome and survival from sudden cardiac arrest. It also describes how Q-CPR can be used to provide timely feedback on compression and ventilation activity during CPR.

NOTE: This application note discusses the CPR meter used with Q-CPR vs. the compression sensor. The sensor was the first compression measurement accessory utilized by the HeartStart MRx monitor/defibrillator and has since been replaced by the CPR meter.

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CPR: A Brief Historical Look

Modern CPR, with the establishment of mouth-to-mouth ventilation and closed–chest cardiac compression steps, has been in existence since the late 1950s and early 1960s. It is a critical link in the American Heart Association's (AHA) 'Chain of Survival'.[5] Related standards and guidelines for compression and ventilation were published over 35 years ago[6] and have been updated many times, most recently in 2010.[7,8] The importance of well-performed bystander CPR has been demonstrated to be a determining factor in survival from sudden cardiac arrest; however, survival rates remain low.[9]

There are clear indications that CPR is a weak link in the Chain of Survival and there is need for improvement in the timing, efficiency, and overall quality in performing CPR. For example, the BLS rescue breathing and chest compression skills are not always mastered or adequately retained by laypeople, or even by all healthcare professionals.[10,11] Despite efforts to simplify the CPR delivery process in the 2005 resuscitation guidelines, compliance with the guidelines remained poor immediately after subjects completed a CPR training course.[12] Verplancke et al. identified similar quality issues amongst hospital nursing staff who performed shallow and slow compressions in the study they conducted.[13]

Also, CPR parameters in actual practice have not been routinely measured and, therefore, the quality of CPR performed in the field has not been known.[3]

Assessing CPR Quality

Good CPR involves early intervention that provides:

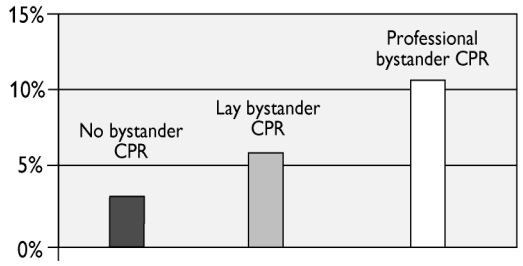
- chest compressions at the correct depth and rate, with complete release and minimal interruption, and
- ventilation at the correct rate.

A look at the following studies establishes why the quality of CPR is important and the current state of compliance with CPR performance guidelines.

Study 1 - Impact of CPR

First, it is safe to say that CPR is a powerful intervention and the sooner it can be performed, the better. In a 12-year study from the Swedish Cardiac Arrest Registry and Herlitz et al. involving over 17,000 patients with bystander-witnessed cardiac arrest, lay bystander CPR doubled the survival rate at one month (6.2%) and health care professional bystander CPR more than tripled the survival rate (10.8%) compared to no bystander CPR (3.1%), as depicted in Figure 1.[1]

Figure 1 **Patient survival rate doubles and triples**



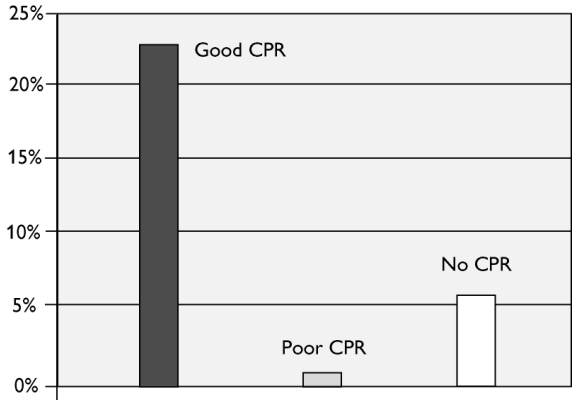
The importance of CPR quality is demonstrated in the next three studies – the first involving bystanders and the others professional out-of-hospital personnel.

Study 2 - Quality of Bystander CPR

Wik et al. evaluated the influence of the quality of bystander CPR on the outcome of out-of-hospital cardiac arrest victims and determined that good bystander CPR was linked to a higher proportion of patients who left the hospital alive (23%) compared with poor CPR (1%) or no CPR at all (6%), as shown in Figure 2.[2] There was no significant difference between poor CPR and no CPR.

Good CPR was defined as a palpable carotid or femoral pulse and intermittent chest expansion with inflation attempts.

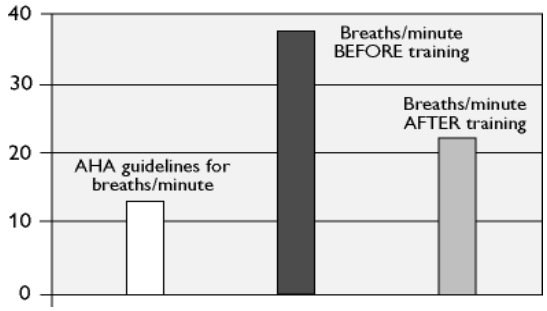
Figure 2 **Good CPR increases survival rate**



Study 3 - Quality of Ventilation

Aufderheide et al. studied ventilation rate administrated by EMS personnel to 13 patients and found an average of 30 breaths/min. compared with AHA 2000 recommendations of 12-15 breaths/min., even after CPR retraining, as shown in Figure 3.[14] They also reported that hyperventilation in a porcine cardiac arrest model resulted in increased positive intrathoracic pressures, decreased coronary perfusion, and decreased survival rates.

Figure 3 **Ventilation rates exceed guidelines**



Aufderheide et al. concluded that their study findings have "significant implications for the interpretation and design of resuscitation research, CPR guidelines, clinical practice, and development of future CPR devices, and EMS quality assurance."

Addressing CPR Quality Improvement

The aforementioned studies suggest the need for tools and techniques to assist in the delivery of quality CPR to improve patient outcomes. To address this need, a number of studies have examined options for improvements that go beyond established classroom training techniques. One option that has shown great potential is audible or voice feedback, as demonstrated in the following manikin studies.

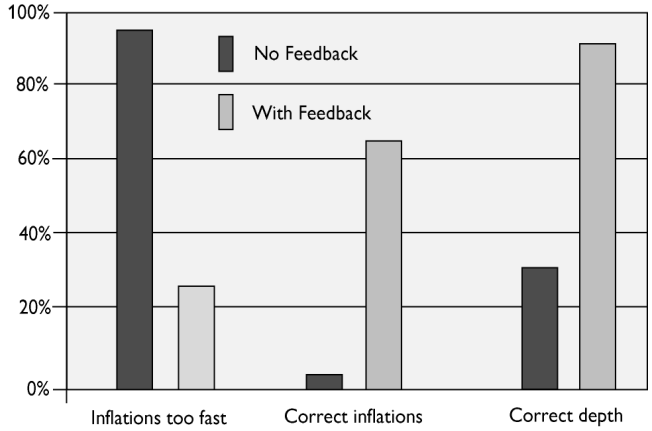
Study 1 - Audio Feedback Impact on CPR by Paramedic Students

Wik et al. determined that an automatic voice-based manikin feedback system (developed by Laerdal - Stavanger, Norway) could be used to improve the quality of basic life support performed by two groups of paramedic students, without the presence of a CPR instructor.[15] Group 1 started without audio feedback and performed poorly. Then, they demonstrated a significant improvement during the first 3 minutes of CPR with feedback in the following categories:

- too fast inflations (reduced from 94 to 25% of the time),
- correct inflations (increased from 2 to 64%), and
- correct compression depth (increased from 32 to 92%).

Figure 4 illustrates these findings.

Figure 4 **Feedback improves ventilation and compression quality**



Group 2 started with feedback, attaining a similar performance to Group 1 and maintaining CPR improvement even AFTER the audio feedback was turned off.

Study 2 - Audio Feedback Impact on CPR by Nurses

Handley et al. concluded that, when using the same audible feedback system Wik et al. used in their study, a group of nurses receiving feedback were significantly better than a control group (who received no feedback) at performing inflations and achieving the correct depth of chest compressions.[16] The authors concluded that CPR skill retention is a problem and suggested that incorporating an audio feedback system into a defibrillator could lead to better CPR performance.

Study 3 - Audio Feedback Impact on CPR by Prehospital Personnel

Hostler et al. demonstrated that the voice-assist manikin (VAM) feedback system, when used by prehospital personnel (EMT-B, EMT-P, and PHRN), attenuated the degradation of compression and ventilation performance over a 3-min. period, as presented in Table 1.[17]

Table 1 **Feedback prevents performance degradation**

Variable	VAM Feedback	30 secs.	60 secs.	120 secs.	180 secs.
Correct inflations (mean%)	ON	61.3	57.3	59.8	58.8
	OFF	70.6	57.6	51.8	47.9
Correct compressions (mean%)	ON	56.5	60.0	68.1	68.0
	OFF	56.0	53.1	52.1	48.8

Study 4 - Audio Feedback Impact on CPR Skill Retention

Wik et al. evaluated the retention of CPR skills 6 months after training of lay responders on a VAM feedback system.[18] The initial training improved all variables; however, when tested again at 6 months without feedback, performance dropped back to the pre-training level. Then, when retested with the feedback system turned on, both the compression and ventilation performance returned to the level immediately after training. In a subsequent paper, the same authors retested the trainees' skills after 12 months and found the same effect, concluding that subjects trained with computer-based voice advisory feedback performed CPR with no deterioration in feedback-supported performance at 12 months.[19]

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CPR Quality Improvement and Education: A Focused Solution

At this point, we can conclude:

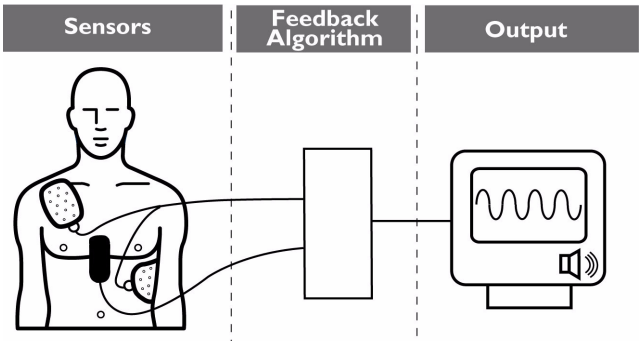
- the quality of CPR is essential and that it affects patient outcome (survival),
- current CPR quality and non-compliance to established guidelines should be of great concern, and
- implementation of tools to assist in the delivery of CPR makes sense.

Laerdal and Philips Innovation

As a world leader in CPR training and therapy solutions, Laerdal is focused on implementation of quality CPR support tools. It established the Sister Research Program in 1998 to improve patient therapy and obtain better outcomes. CPR quality and efficiency have been a primary program initiative, and automated verbal and visual feedback has become a critical technological output from the company's efforts, as utilized in the four studies just presented. Essentially, as illustrated in Figure 5, Laerdal (along with Philips) has developed the capability to:

- measure CPR performance (through appropriate sensors),
- find the gap between actual and correct CPR (through a feedback algorithm), and
- give verbal and visual feedback.

Figure 5 **CPR measurement and feedback technology**



Some of the benefits of this type of feedback are that it is:

- **Corrective** so the caregiver is advised on compression or ventilation performance only when needed and can refresh their CPR skills with each use
- **Objective** in that it comes from the defibrillator, not another individual on the scene
- **Concise** to allow the caregiver to react quickly
- **Accurate** so the caregiver can 'measure' their actions for optimal ventilation and compression performance
- **Immediate** to reduce 'no flow' time (i.e., time when no CPR activity is taking place but ideally should be)
- **Prioritized based on clinical importance** so the caregiver is advised as to which aspect of their CPR performance most needs attention (e.g., compression depth over compression rate)

CPR Measurement and Feedback incorporated into a Monitor/ Defibrillator

Laerdal and Philips Healthcare, a world leader in cardiac resuscitation solutions, incorporated this measurement and feedback technology into a prototype HeartStart 4000SP defibrillator. A chest compression sensor (designed by Laerdal) to measure compressions and multifunction electrode pads to measure ventilations were connected to the defibrillator. The defibrillator also contained CPR quality analysis software to provide the CPR audio/visual feedback components. The HeartStart 4000SP was then used in two separate studies to determine the quality of CPR in the real world, one focused on out-of-hospital cardiac arrest and the other on in-hospital cardiac arrest. The significance of these studies, which are described as follows, is that they represent the first time objective data was collected to measure the quality of CPR (as defined by international guidelines) delivered to actual resuscitation patients.

Study 1 - Quality of Out-of-hospital CPR

In the out-of-hospital study, Wik et al. examined the performance of paramedics and nurse anesthetists based on their adherence to international CPR guidelines while treating 176 patients with cardiac arrest.[4] They determined that:

- chest compressions were given only about half (48%) of the time that the patient had no spontaneous circulation during the resuscitation events and

- only 28% of compressions given met the guideline recommendations for depth.

It is interesting to note that the paramedics and anesthetists, who had previous ACLS training with regular retraining, had all completed a refresher course immediately prior to study participation.

Study 2 - Quality of In-hospital CPR

In the in-hospital study, Abella et al. measured CPR quality parameters and assessed compliance to AHA and international guidelines by well-trained BLS/ALS staff during 67 instances of cardiac arrest.[3] It was determined:

- compressions were administered at a low rate (<90/min.) 28% of the time,
- 37% of the compressions delivered were too shallow,
- mean proportion of time without compressions while patients were in cardiac arrest was 24%, and
- ventilation rates were higher than 20/min. just over 60% of the time.

It is worth noting that chest compressions appear to be the most important factor regarding good-quality CPR, according to both human and animal studies, and even short 4- to 5-second interruptions in compressions decrease coronary perfusion pressure.[20-23]

In a revealing JAMA editorial, Sanders and Ewy directly addressed the quality of CPR (citing several of the same studies mentioned throughout this application note) and the need to update CPR and Emergency Cardiovascular Care (ECC) guidelines, given the poor survival rates from cardiac arrest.[24] One aspect of CPR performance they touched on was the need to change the model for training health care personnel and lay persons in CPR: "Perhaps only those elements that are most critical for neurologically intact survival from cardiac arrest should be taught---such as the following elements for out-of-hospital sudden cardiac collapse: push hard and push fast on the center of the chest without interruption, defibrillate promptly, and don't provide too many rescue breaths per minute."

Q-CPR®: The Measurement and Feedback Solution

To help caregivers perform high quality CPR, Philips Healthcare and Laerdal offer the Q-CPR Measurement and Feedback tool in the Philips HeartStart MRx monitor/defibrillator. Q-CPR is the world's first and only real-time CPR measurement and feedback tool to provide objective measurement and real-time corrective feedback on both the compression and ventilation components of CPR. Q-CPR Measurement and Feedback is available in both manual defibrillation and AED modes on compression depth and rate as well as ventilation rate to encourage caregivers to perform CPR on adults (8 years of age or older or weighing more than 25 kilograms/55 lbs.) in accordance with AHA/ERC guidelines.

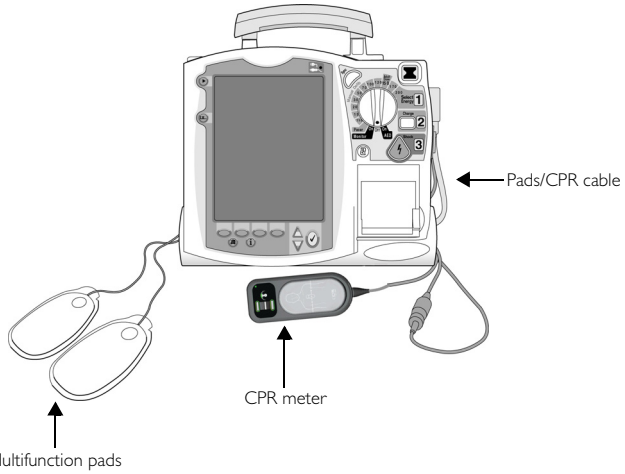
Overview

Q-CPR is easy to set up, use, and experience. It consists of:

- a pads/CPR cable,
- a lightweight (8.9 ounces) reusable CPR meter, and
- Philips multifunction defibrillation electrode pads.

Figure 6 illustrates the Q-CPR configuration.

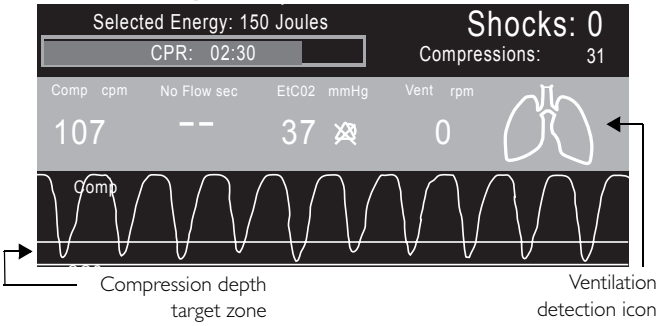
Figure 6 **HeartStart MRx with Q-CPR**



The multifunction pads are placed on the patient's chest and the CPR meter is applied to the center of the patient's chest. During use, the CPR meter measures chest compression depth and rate while a ventilation

algorithm analyzes chest impedance measured from the multifunction pads to produce a ventilation rate. An anterior/anterior pads placement is required because the algorithm interprets change in impedance based on the apex/sternum placement. The compression and ventilation algorithms produce visual measurements and related auditory/textual feedback, as appropriate, through a feedback algorithm. Figure 7 is a sample screen of the Advanced Q-CPR View depicting the various compression and ventilation measurements, as well as a CPR timer and compression counter.

Figure 7 **Q-CPR in Advanced View: *Good Compressions***

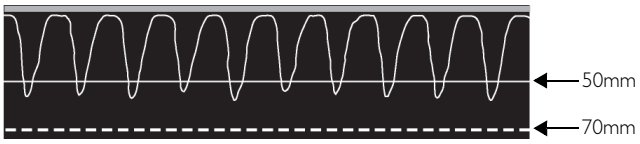


Compressions

Compression depth is presented (in Figure 7) as a waveform (labeled 'Comp') that represents about 10 seconds of compressions, as derived from signals from the CPR meter. As the chest is compressed, the compression is represented as a downward stroke of the wave, rebounding up to a baseline as compression pressure is released. For a MRx with software version F.01/R.01, two horizontal lines in the wave sector drawn at 40mm/1.5" and 50 mm /2" indicate the target zone to help achieve good compression depth.

For a MRx using software version F.02/R.02 or later, you can configure the target zone for AHA or ERC 2010 CPR guidelines. For AHA guidelines, a solid horizontal line drawn at 50 mm/2" indicates the minimum recommended compression depth when the patient is on a firm surface and a dashed line at 70 mm/2.75" indicates the manufacturer's recommended minimum compression depth for performing CPR on a surface that yields, such as a mattress, when a backboard is in place. See Figure 8.

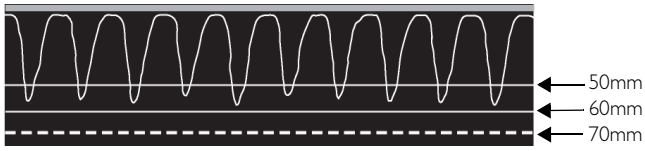
Figure 8 **Target zone for AHA guidelines**



For ERC 2010 CPR guidelines, three lines are drawn, as in Figure 9:

- 50 mm/2" - A solid line indicates the minimum depth recommended when the patient is on a firm surface.
- 60 mm/2.4" - A solid line indicates the maximum depth recommended when the patient is on a firm surface.
- 70 mm/2.75" - A dashed line indicates the manufacturer's recommended minimum compression depth for performing CPR on a surface that yields when a backboard is in place.

Figure 9 **Target zone for ERC guidelines**



A calculated compressions-per-minute (cpm) rate is displayed in the upper left corner above the wave. If compression depth or rate deviate significantly from AHA/ERC guidelines, the monitor/defibrillator provides visual and corrective audible feedback. If there are no detectable compressions, a No Flow time value will count "hands off" seconds, starting at 2 seconds and incremented with each additional second.

Ventilations

The defibrillation pads collect ventilation data by detecting changes in thoracic impedance. The ventilation rate is presented as ventilations-per-minute (vpm) and the ventilation detection icon above and to the right of the compression wave lights when a ventilation is detected. Like compression, if the ventilation rate falls outside the AHA/ERC guidelines, visual and audible feedback are given.

Corrective Feedback

Audible voice prompts (in manual and AED modes) and MRx on-screen text prompts (in AED mode - Basic View only) alert the caregiver to needed adjustments in CPR performance, including a lapse in compression activity. Feedback is organized as shown in Table 2:

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Table 2 **CPR feedback**

Category	Performance addressed
Compression depth	Too shallow
Compression rate	Too slow; too fast
Residual pressure on the patient's chest	Incomplete release of compression
Ventilation rate	Too high
No compression activity	15, 30, 45, or 60 seconds without sign of compression
Poor pad/patient contact	Pads are on the patient but impedance is greater than 200 ohms or less than 25 ohms.

Feedback is prioritized and delivered in the order of clinical importance. The feedback is also tiered so the caregiver receives visual feedback first and then a voice prompt only if a correction is not made based on the initial visual prompts. The volume of voice prompts can be adjusted or they can be muted altogether.

The following figures are two examples of feedback. Figure 10 shows the Advanced View* (available in manual defib and AED modes) with shallow compressions preceding a break for ventilation. The flat compression waveform to the right and 'No Flow' value indicate no compression activity.

*Manual defib mode displays Advanced View only. AED mode can be configured to display Advanced View.

Figure 10 **Q-CPR in Advanced View: *Poor Compressions plus Ventilations***

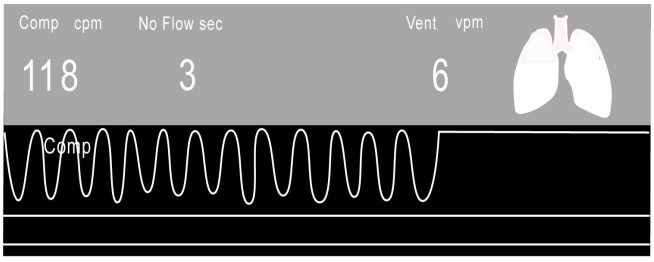
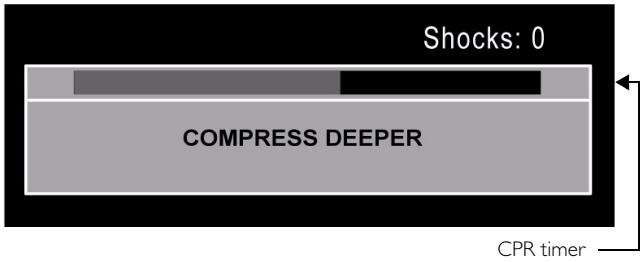


Figure 11 shows the default Basic View in AED mode where compressions are, again, too shallow and "Compress deeper" audio and text feedback is produced. A configurable CPR Timer status bar is also displayed.

Figure 11 **Q-CPR in Basic View: *Poor Compressions***



In both examples, once a correction is made, the related feedbacks disappear.

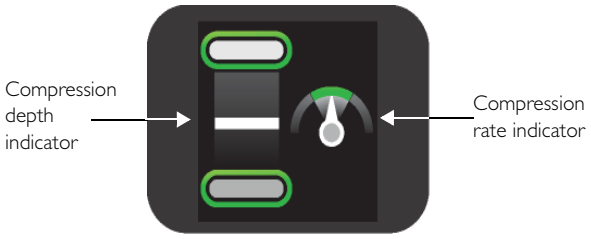
The benefits of providing visual and auditory feedback are depicted in a study by Kramer-Johansen et al. involving ***out-of-hospital*** CPR.[25] With the introduction of feedback:

- average compression depth increased,
- the percentage of compressions with correct depth doubled,
- average compression rate (which tended to be higher than guidelines recommendations *before* feedback was introduced) fell, and
- the proportion of 1-minute segments with excessively high ventilation rates was reduced significantly.

Abella et al. demonstrated CPR quality improvement during ***in-hospital*** cardiac arrest while also using audio and visual feedback.[26] In particular, chest compression rate, ventilation rate, and No Flow time improved during resuscitation efforts on patients supported by real-time feedback.

Speaking of such feedback, the CPR meter used with the HeartStart MRx provides real-time visual feedback once compressions begin. Figure 12 depicts the meter's display that lets you know if your compressions are at the appropriate depth and rate, and with complete release between compressions.

Figure 12 **CPR meter display**



Additional Benefits

In addition to supporting real-time CPR performance, Q-CPR can:

- reinforce skills with each and every use,
- provide event data to demonstrate CPR guideline adherence (with optional data recording feature),
- provide event data to illustrate areas for improvement (with optional data recording feature),
- identify the most critical factors in successful CPR for future study, and
- acquire CPR parameter data associated with survival for future study (with optional data recording feature).

Real-time Measurement and Feedback with Retrospective Performance Debriefing

As suggested from the above list, Q-CPR data can provide powerful retrospective insight. Edelson et al. examined and demonstrated Q-CPR's impact when combined with debriefing intervention after CPR performance involving actual in-hospital cardiac arrests.[27] During the debriefing, members from various resuscitation teams (including cardiologists, anesthesiologists, and emergency medicine physicians) reviewed Q-CPR and other clinical data captured by the MRx during a resuscitation, including electrocardiology, chest compressions, ventilations, end-tidal carbon dioxide waveforms, and audio feedback notations received during the resuscitation. This intervention identified areas for improvement that resulted in better compressions and ventilations, and an increased rate of ROSC. In particular, mean compression depth and rate increased while mean ventilation rate and no-flow time decreased. These changes correlated with an increase in the rate of return of spontaneous circulation (59.4% vs. 44.6%). The combination of real-time measurement and feedback during resuscitation with retrospective review of the Q-CPR data also has broad applicability for improving resuscitation education in both in-hospital and out-of-hospital settings.

Conclusion

Recent science provides a better understanding of the importance of CPR and how to optimize its benefits. Also, by calling attention to the current state of CPR, research encourages caregivers, advisory boards, and the medical products industry to:

- assess practices and guidelines and
- develop procedures, techniques, and tools to better address the reality of actual CPR performance.

There is no question that performing quality CPR is challenging in the real world. The environment, patient type, fatigue, and even training all affect performance. One promising advancement to help mitigate these factors is Laerdal's Q-CPR® technology integrated into Philips' HeartStart MRx monitor/defibrillator. It is the first monitoring parameter to provide immediate, objective measurement and corrective feedback on compression and ventilation to encourage CPR performance in accordance with established guidelines.

Further research will likely bear out that this more complete understanding of CPR quality, along with advances in its delivery, will positively impact patient care. The data generated by Q-CPR may also contribute to refinements of guidelines and teaching practices. All told, better patient outcomes and improved survival rates should be anticipated.

References

1. Herlitz J, Svensson L, Holmberg S, et al. Efficacy of bystander CPR: Intervention by lay people and by health care professionals. *Resuscitation*. 2005; In Press.
2. Wik L, Steen PA, Bircher NG. Quality of bystander cardiopulmonary resuscitation influences outcome after prehospital cardiac arrest. *Resuscitation*.1994; 28:195-203.
3. Abella B, Becker L, et al. Quality of cardiopulmonary resuscitation during in-hospital cardiac arrest. *JAMA*. 2005; 293:305-310.
4. Wik L, Kramer-Johansen, Myklebust H, et al. Quality of cardiopulmonary resuscitation during out-of-hospital cardiac arrest. *JAMA*. 2005; 293:305-310.
5. Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiac Care. *JAMA*. 1992; 268(suppl): 2171-2302.
6. Standards for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC), V: medicolegal considerations and recommendations. *JAMA*. 1974; 227(suppl):864-866.
7. American Heart Association 2010 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation.* 2010:122:18, suppl 3.
8. European Resuscitation Council Guidelines for Resuscitation 2010. *Resuscitation*. 2010; 81:1219-1276.
9. Larsen MP, Eisenberg MS, Cummins RO, Hallstrom AP. Predicting survival from out-of-hospital cardiac arrest: a graphic model. *Ann Emerg Med*. 1993; 22:1652-1658.
10. Kaye W, Mancini ME. Retention of cardiopulmonary resuscitation skills by physicians, registered nurses, and the general public. *Crit Care Med*. 1986;14:620-622.
11. Broomfield R. A quasi-experimental research to investigate the retention of basic cardiopulmonary resuscitation skills and knowledge by qualified nurses following a course in professional development. *J Adv Nurs*. 1996; 23:1016-1023.
12. Perkins G, Boyle W, et al. Quality of CPR during advanced resuscitation training. *Resuscitation*. 2008; 77: 69-74.
13. Verplancke T, de Paepe P, et al. Determinants of the quality of basic life support by hospital nurses. *Resuscitation*. 2008; 77: 75-80.
14. Aufderheide TP, Sigurdsson G, Pirallo RG, et al. Hyperventilation-induced hypotension during cardiopulmonary resuscitation. *Circulation*. 2004;109:1960-1965.
15. Wik L, Thowsen J, Steen PA. An automated voice advisory manikin system for training in basic life support without an instructor: a novel approach to CPR training. *Resuscitation*. 2001; 50:167-172.
16. Handley AJ, Handley SA. Improving CPR performance using an audible feedback system suitable for incorporation into an automated external defibrillator. *Resuscitation*. 2003; 57:57-62.
17. Hostler D, Wang H, Parrish K, et al. The effect of a voice assist manikin (VAM) system on CPR quality among prehospital providers. *Prehospital Emergency Care*. 2005; 9:53-60.
18. Wik L, Mykleust H, Auestad B, Steen PA. Retention of basic life support skills 6 months after training with an automated voice advisory manikin system without instructor involvement. *Resuscitation*. 2002; 52:273-279.
19. Wik L, Mykleust H, Auestad B, Steen PA. Twelve-month retention of CPR skills with automatic correcting verbal feedback. *Resuscitation*. 2005; In Press.
20. Van Hoeyweghen RJ, Bossaert LL, Mullie A, et al. Belgian Cerebral Resuscitation Study Group. Quality and efficiency of bystander CPR. *Resuscitation*. 1993; 26:47-52.
21. Marn-Pernat A, Weil MH, Tang W, et al. Optimizing timing of ventricular defibrillation. *Crit. Care Med*. 2001: 29: 2360-2365.
22. Yu T, Weil MH, Tang W, et al. Adverse outcomes of interrupted precordial compressions during automated defibrillation. *Circulation*. 2002;106:368-372.
23. Berg RA, Sanders AB, Kern KB, et al. Adverse hemodynamic effects of interrupting chest compressions for rescue breathing during cardiopulmonary resuscitation for ventricular fibrillation cardiac arrest. *Circulation*. 2001;104:2465-2470.
24. Sanders A, Ewy G. Cardiopulmonary resuscitation in the real world: When will the guidelines get the message? *JAMA*. 2005; 293:363-365.

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25. Kramer-Johansen, Myklebust H, Wik L, et al. Quality of out-of-hospital cardiopulmonary resuscitation with real time automated feedback. *Resuscitation*. 2006; 71:283-292.
26. Abella B, Edelson D, et al. CPR quality improvement during in-hospital cardiac arrest using a real-time audiovisual feedback system. *Resuscitation*. 2007; 73:54-61.
27. Edelson D, Becker L, Abella, B, et al. Improving in-hospital cardiac arrest process and outcomes with performance debriefing. *Arch Intern Med* 2008; 168 (10): 1063-1069

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